

16. (New) A wavelength monitoring apparatus according to claim 1 further comprising a reflective layer positioned on a surface of said periodic multilayer structure parallel to said layer surfaces and opposite to said one surface.

5 17. (New) A wavelength monitoring apparatus according to claim 10 further comprising a reflective layer positioned on a surface of said periodic multilayer structure parallel to said layer surfaces and opposite to said second surface.

### REMARKS

10 Claims 1-13 are active in the application.

Fig. 11 is being amended to include the notation "Related Art". A request for approval of drawing changes is filed herewith.

15 Claims 1-13 were rejected under 35 USC 112, second paragraph as being indefinite. These rejections are traversed.

With regards to claim 1, the Examiner states that claim 1 "fails to recite any periodic multilayer structure...". This is incorrect because claim 1 (as amended) recites "an optical device having a periodic multilayer structure". The Examiner also suggests that claim 1 is indefinite for lacking a structural relationship in order to support the claim.

20 Claim 1 has been amended to make it more clear and thereby traverse the 35 USC 112 rejection. For example, "not parallel" has been replaced with "non-parallel", and "with respect to" has been replaced with "for", and "made to exit" has been replaced with "exiting". These changes render claim 1 definite and clear and provide structural relationships to support the claim. It is noted that the "one end surface" recited in claim 1

25 corresponds to "end surface 1a" described on pages 8-9 of the specification, and illustrated in Figs. 1, 6, and 7.

With regards to claim 10, the Examiner states that the claim recites a semiconductor laser "without any structure". Semiconductor lasers are well known in the art, and so structure is not necessary to support the claim. In order to make the claim more

30 clear, the phrase "confronted with" has been replaced with "disposed to direct light towards" in reference to the laser, and the same phrase has been replaced with "disposed

to receive light from" in reference to the photo-detector. The "first surface" recited in claim 10 corresponds to "end surface 1a" described on pages 8-9 of the specification, and illustrated in Figs. 1, 6, and 7. The "second surface" recited in claim 10 corresponds to (in some embodiments) rear surface 12b described on page 16, lines 14-16 and page 19 lines 4-6, and illustrated in Figs. 6 and 7. Also, in response to the Examiner's statements, 35 USC 112 does not *require* "recitation of means plus function".

New claims 14 and 15 are supported by the structure shown in Figure 10 of the application where layers of silicon and layers of air alternate to make the periodic multilayer structure (see page 20 lines 6-18 of the application).

New claims 16 and 17 are supported by the structure shown in Figure 6 of the application where the reflective layer 17 is positioned on the multilayer structure on the side opposite the detector (see page 16, line 24 of the application).

Claims 1, 10 were rejected under 35 USC 102(b) as being anticipated by US patent 5,111,466 to Normandin et al. Given the statements made on page 3 of the office action, it appears that the Examiner intended to reject all of claims 1-13 as being anticipated by Normandin. This rejection is traversed by amendment.

The present invention provides a wavelength monitoring device having multiple layers of dielectric material. The layers are arranged in a periodic structure, and form a one-dimensional photonic bandgap material. Light from a laser injected parallel to the layers is coupled out of the layers at an angle that sensitively depends on wavelength. It has been found that by detecting the angle that light leaves the multilayer structure, monitoring of the wavelength is provided. The Examiner's attention is directed to Figure 1 of the application, and to the text bridging pages 8 and 9 of the application. There it is explained that when an incident beam 3 of a specific wavelength passes through a multilayer film, a large part of the beam is guided straight through, but that a portion of the beam is leaked to the substrate 2 side. Further, it has been observed that the leaked beam 5 forms a luminous flux of good directivity that varies in accordance with the value of the specific wavelength. Thus, changes in wavelength of the incident beam can be detected as a change in the angle of the leakage beam with high sensitivity. The Examiner's attention is also directed to the paragraph bridging page 12 of the application, where it is explained that the device of this invention provides for high-resolving-power

wavelength separation. This is because the angle of the refracted beam with respect to the corresponding guided beam is kept approximately constant.

U.S. Patent 5,111,466 to Nomandin is directed to a completely different type of optical device than the claimed invention. Nomandin is directed to a harmonic emission device which uses optically non-linear characteristics to mix and convert two wavelengths which are input into a multilayer film into a third, different wavelength. In contrast, the present invention is designed to monitor the fluctuation of a wavelength of light inputted to a multilayer film. The present invention does not perform the function of changing a wavelength or converting two inputted wavelengths into a different wavelength as is the case with Nomandin. Accordingly, the technology to which the present invention is applied is completely different from the technology of Nomandin.

In short, the difference between Nomandin and the present invention is whether the characteristic used is non-linear or linear. In more detail, Nomandin is directed to a device into which two wavelengths are inputted and from which a wavelength different from the inputted two wavelengths is outputted. In contrast, the present invention is directed to a device into which a specific wavelength is inputted and from which a specific wavelength is outputted without conversion.

Independent claims 1 and 10 specify that the beam detection means or photodetector, respectively, detect light of a specific angle for a specific wavelength. Nowhere in Nomandin is this feature specified or suggested. As noted above, this feature can be used for high resolution wavelength separation (which is not performed in Nomandin). Since the feature is wholly lacking from Nomandin, and is not present in any of the other references of record, claims 1 and 10 should be patentable over Nomandin.

Regarding claims 2 and 12, Normandin et al. do not teach a transparent substrate for supporting the multilayer structure. In fact, Normandin et al. only show that the harmonic frequencies are extracts from a *top* of the multilayer structure (see Fig. 9), thereby avoiding transmission of the harmonic light through the substrate.

Regarding claim 8, Normandin et al. does not teach or suggest locating the photodetector on a surface of the substrate opposite the multilayer structure. Normandin et al. only show the photodetector and multilayer structure on the same side of the substrate.

6, | Regarding claims 14 and 15, Nomandin does not show or suggest a multilayer structure composed of lanes of air separated by lanes of silicon.

In view of the foregoing, it is respectfully requested that the application be reconsidered, that claims 1-17 be allowed, and that the application be passed to issue.

5 Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

10 A provisional petition is hereby made for any extension of time necessary for the continued pendency during the life of this application. Please charge any fees for such provisional petition and any deficiencies in fees and credit any overpayment of fees for the petition or for entry of this amendment to Attorney's Deposit Account No. 50-2041 (Whitham, Curtis & Christofferson P.C.).

15 Respectfully submitted,



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## APPENDIX 1

Clean copies of the amended sections of the specification:

5 Paragraph beginning at page 5, line 9 now reads as follows:

A1  
10 In the wavelength monitoring apparatus according to the present invention, the fluctuation of the wavelength is detected as a change of the exit angle by the operation of the periodic multilayer structure which functions as a one-dimensional photonic crystal. Because the change of the exit angle is more sensitively dependent upon wavelength, compared with that in a background-art diffraction grating or the like, the size of the apparatus can be reduced as a whole. In addition, because such a periodic multilayer structure is generally formed on a substrate, the periodic multilayer structure is suitable for integration of the beam source and the beam detecting means on one and the same substrate. Hence, optical parts such as a lens, and so on, are not required, so that a  
15 wavelength monitoring apparatus small in size and excellent in stability can be provided.

Paragraph beginning at page 7, line 12 now reads as follows:

A2  
20 In most cases, an optical multilayer film is used by passing beam rays through the uppermost layer surface to the lowermost layer surface of the multilayer film. The present invention is different in that an end surface of the multilayer film (a surface where the periodic structure is exposed) is used as a beam incidence surface or as a beam exit surface.

Paragraph beginning at page 8, line 20 now reads as follows:

A3  
25 According to the inventors' experiment, when laser beam (incident beam) 3 with a wavelength  $\lambda$  is incident on an end surface 1a of the multilayer film 1 after the end surface 1a is polished, a large part of beam serves as guided beam 4 inside the multilayer film 1. A part of guided beam 4, however, becomes beam 5 leaked to the substrate 2 side. Moreover, because the value of  $\theta$  varies greatly with the value of  $\lambda$ , the multilayer film 1  
30 can detect the change of the wavelength of the incident beam 3 as a change of the angle  $\theta$  with high sensitivity.

## APPENDIX 2

Clean copies of the amended and new claims:

- A4
- 5 1. A wavelength monitoring apparatus comprising:  
an optical device made of a periodic multilayer structure;  
a beam source optically coupled to at least one end surface of said periodic multilayer structure, said one end surface being non-parallel to layer surfaces of said periodic multilayer structure; and
- 10 beam detection means for detecting a light beam exiting from at least one surface of said periodic multilayer structure at a specific angle for a specific wavelength, said one surface being parallel to said layer surfaces of said periodic multilayer structure.

- AS
- 15 10. A wavelength monitoring apparatus comprising:  
an optical device having a periodic multilayer structure,  
said periodic multilayer structure having a first surface substantially perpendicular to layer surfaces of the periodic multilayer structure and a second surface substantially parallel to the layer surfaces of the periodic multilayer structure;  
a semiconductor laser disposed to direct light towards said first surface; and
- 20 a photo detector disposed to receive light from said second surface.

- Ab
- 25 14. A wavelength monitoring apparatus according to claim 1, wherein said optical device made of a periodic multilayer structure comprises layers of silicon separated by layers of air.

15. A wavelength monitoring apparatus according to claim 10, wherein said optical device having a periodic multilayer structure comprises layers of silicon separated by layers of air.

- 30 16. A wavelength monitoring apparatus according to claim 1 further comprising a reflective layer positioned on a surface of said periodic multilayer structure parallel to said layer surfaces and opposite to said one surface.

17. A wavelength monitoring apparatus according to claim 10 further comprising a reflective layer positioned on a surface of said periodic multiplayer structure parallel to said layer surfaces and opposite to said second surface.

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